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Effects of coherence in nuclear and hadronic collisions

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The light-cone QCD approach incorporating the effects of the nonperturbative interaction between produced quarks and gluons suggested in [1] is applied in [2] to calculation of nuclear shadowing for longitudinal and transverse photons. This work was motivated by the results of the HERMES experiment observed unusual shadowing at small Q^2 where perturbative methods cannot be used. Although an exciting effect of strong dependence of the coherence length on the photon polarization was discovered in [2], data of HERMES remain unexplained.

The strong nonperturbative interaction of radiated gluons leads not only to a substantially weaker shadowing in heavy ion collisions, but also for the first time explains the observed smallness of large mass diffraction and allows to explain in a parameter free way the energy dependence of elastic scattering of hadrons [3, 4] in a good agreement with data.

The phenomena related to propagation of fast partons through medium are important for prediction of the initial condition in heavy ion collisions and also for the so called jet quenching probe for the produced matter. Broadening of the transverse momentum of a quark propagating through nuclear medium is calculated in [5]. It is found to be a color filtering effect and expressed in terms of the universal color dipole cross section which is fitted to data for the proton structure function. The calculated broadening of p_T for a quark propagating through a nucleus is somewhat larger than what was measured in Drell-Yan reaction on nuclei.

Energy loss of a quark propagating through nuclear matter can be also measured in Drell-Yan reaction. The main problem is to discriminate between this effect and nuclear shadowing. This is done in [6] employing our experience in parameter free calculation of shadowing. The analysis of data for Drell-Yan reaction from the E772 and E866 experiments at Fermilab resulted in a rather large rate of energy loss $dE/dz \approx -2 \text{ GeV}/fm$. This is the first observation of a nonzero energy loss effect.

It is usually believed that energy loss leads to baryon stopping in heavy ion collisions. A different point of view is presented in [7] where it is shown that the dominant mechanism of stopping is baryon number transfer by gluons. Nearly the same stopping is expected at RHIC as at SPS, as is confirmed by the preliminary data from RHIC.

Charmonium suppression is considered as one of the main probes for creation of a hot deconfined matter in relativistic heavy ion collisions. The conventional base line for search of new physics relates charmonium suppression to simple absorption in cold nuclear matter. First of all, one needs to know the charmonium-nucleon cross section. It is predicted in [8] quite reliably employing the light-cone dipole formalism with the realistic charmonium wave functions and phenomenological dipole cross section fitted to DIS data. This method is tested comparing to data

on charmonium photoproduction. The important effect missed in previous calculations is the relativistic spin rotation which increases the production rate of Ψ' by factor of 2-3. The cross sections are predicted for J/Ψ , Ψ' and χ , and with a proper mixture of these states the effective absorption cross section in cold nuclear matter is found.

In heavy ion collisions all nucleons which the produced charmonium interacts with, have already had a chance to interact with other nucleons and are in color-excited states. It is found in [9] that the colored 3-quark system interacts up to about 60% stronger than colorless one. Although this effect is not sufficiently strong to explain the observed anomalous E_T dependence of J/Ψ absorption, it must be included together with other missed effects in the interpretation of the experimental results. In particular, fluctuations of transverse energy should be taken into account, especially for most central collisions. It is demonstrated in [10] that they strongly correlate with fluctuation of charmonium suppression by interaction with the produced medium.

Coherent effects in elastic proton-nucleus scattering are proved to keep unchanged compared to pp scattering the ratio of spin-flip to non-flip amplitudes. This allows to use coulomb-nuclear interference in polarimetry as a basis for polarimetry. This method suggested in [11, 12] is accepted for polarimetry at RHIC.

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